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ROYAL AIR FORCE (part two)

An RAF 'scramble' – pilots race to their Hurricane fighters to engage the enemy

'NEVER in the field of human conflict was so much owed by so many to so few.' These words of Winston Churchill expressed the gratitude of the whole British nation to the gallant men of the RAF during the tense days at the beginning of the Second World War. With only a fraction of the resources of the German *Luftwaffe*, they resisted the might of a giant German offensive. In doing so they enabled the British war effort to be built into the great offensive that was to win the war, and, at the same time, saved their country from invasion.

FIRST-LINE AIRCRAFT, BRITISH, GERMAN, AND ITALIAN

Date	*RAF*	*German*	*Italian*
3rd September 1939	1,911	4,161	–
1st August 1940	2,913	4,549	1,529 (June)

The Second World War broke out on 3rd September 1939. It was soon obvious that air power would be a decisive factor in the war. The unprecedented power of bombers to smash cities, production units, and communications was grimly demonstrated by the *Luftwaffe* as it crushed the Polish Air Force. Against such attacks adequate fighter aircraft provided the only possible answer. And so in Britain RAF leaders anxiously tried to build up their fighter forces and radar devices for the day when the fury of the enemy would be turned on them.

After Hitler's lightning victory in Poland an uneasy period of calm, the so-called 'phony war', began. Then, in the spring of 1940, Germany attacked, and at once the whole pattern of the war changed drastically. Norway, with its valuable harbours, was overrun in April in a campaign that took place beyond the range of British-based RAF fighters. The Germans quickly established supremacy in the air, and two RAF squadrons operating on the spot (one from a frozen lake) were overwhelmed. The Navy sent three aircraft carriers, but the planes they carried were hopelessly outnumbered, and one carrier was sunk.

Then, in May, the German Panzer divisions turned towards France. Holland and Belgium were overrun. The German armies streamed towards Paris, while 3,000 bombers blasted the allied air bases. The 600 British and French fighters could make little headway against such odds, and attempts to retaliate with bombers were a complete failure. German fighters shot down 65 out of 135 RAF Blenheim and Fairey Battle light bombers in the first two days of the battle. Then, in a disastrous attempt at a full-scale counter-attack, the RAF lost 40 more.

It was soon clear that France was collapsing. Both British and French governments appealed to the RAF for more planes in an attempt to stave off the coming disaster. But Air Chief Marshal Sir Hugh Dowding, Commander-in-Chief Fighter Command, refused to send any Spitfires into the suicidal fray, or to add to the 13 Hurricane squadrons already committed. The British government reluctantly agreed that the RAF would send further help only to cover troop evacuations. They could scarcely do otherwise when faced with such staggering losses as the 195 Hurricanes lost out of a total of 261 committed to the defence of France. The losses represented about a quarter of Dowding's total Hurricane forces.

The most spectacular of the troop evacuations which the RAF covered was Dunkirk. 340,000 British and French troops were stranded on the Dunkirk beaches with the German army racing towards them. To evacuate them by sea it was necessary to gain control of the air over the narrow stretch of channel which separated the besieged troops from the safety of British harbours. The RAF succeeded, with a loss of 237 Hurricanes and Spitfires. In this battle – the first in which fighter pilots were directed by radio from the central control – the British pilots proved to the public and themselves that they were, individually, more than a match for the Germans.

Previous page: the RAF aircraft which played a vital role in winning the Second World War. From top to bottom: a Spitfire; Hurricanes in formation; a Mosquito; Lancasters of 617 Squadron – the Dambusters

Order out of chaos: an imaginary drawing of a new Europe rising out of the ruins of the old

EUROPE AFTER THE SECOND WORLD WAR

THERE was nothing like the enthusiasm which had greeted the end of the First World War; nothing like the thrill of hope which, in 1918, welcomed a world 'fit for heroes to live in'. No great summit meeting, like that at Versailles, heralded the dawn of a new age of disarmament, democracy, and universal peace. Instead, in an atmosphere of caution, hesitancy, and suspicion, statesmen took stock of their battleground countries, their shattered cities, their ruined economies, and their disputed frontiers. The problems facing them were far too complex to solve overnight. Some of the problems remain unsolved today. It was only slowly and painfully that a new Europe emerged, established according to the needs of the moment. What was essential was a respite, peace almost at any price. If a strong power asserted itself, few would have the stomach to resist. And so things happened which none pretended were ideal. Suddenly, almost without warning, a new menace appeared. The Soviet Union stood supreme, one foot stretching out towards the eastern extremities of Asia, the other firmly planted in eastern Europe. An 'Iron Curtain' clamped down, dividing Communist Europe from the Western democracies. The Western nations huddled for protection under the mantle of the United States. And so the scene was set for the 'Cold War' – a period of implacable enmity between Russia with her 'satellite' states and the anti-Communist states of the West.

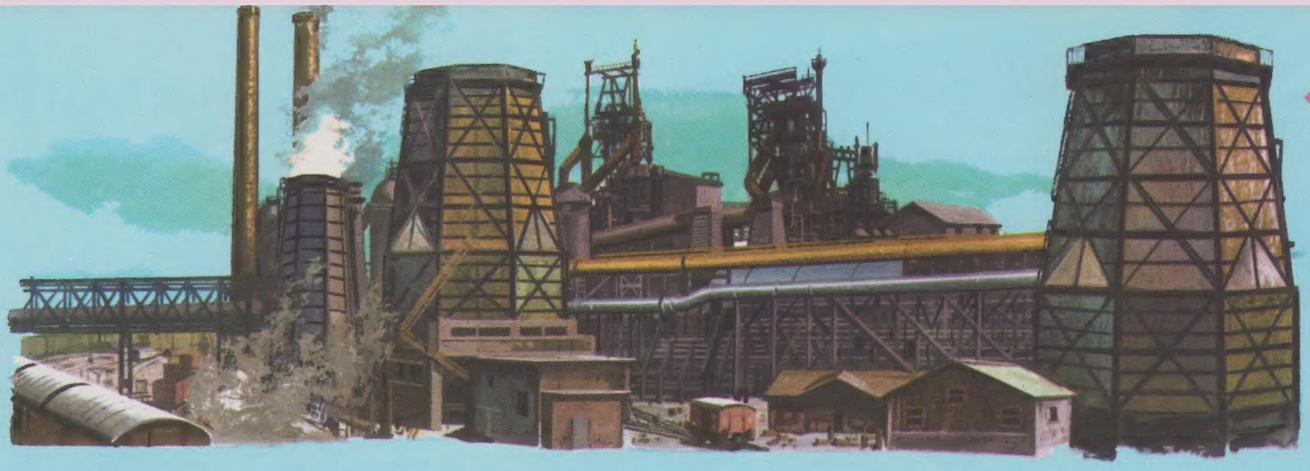
1945–1947: a period of co-operation

On 8th May 1945, which was celebrated by the allies as 'VE-Day', these things seemed far in the future. There appeared to be no reason why the allies should not co-operate in peace-time as they had during the war. Prospects seemed rosy enough. At the Yalta Conference (February 1945), and again at Potsdam (July–August 1945), Britain, Russia, and America found themselves in agreement. They agreed to act jointly during 'the temporary period of instability in liberated Europe'. They also agreed to divide Germany into zones, each administered by one of the victorious allies. Another symptom of the spirit of co-operation was that Russia was permitted the 'plum' of declaring war on Japan on 8th August 1945, two days after the atom bomb was dropped on Hiroshima and only weeks before Japan's inevitable surrender (2nd September). She used her opportunity well, sending troops into Manchuria, seizing Japanese war materials, and leaving them intact for Mao Tse-tung, the Chinese Communist leader, to use in his battle with the Nationalist leader, Chiang Kai-shek. Britain was sceptical from the beginning about the possibility of working in harmony with Russia. But the United States foresaw few dangers, and so Britain reluctantly agreed to the policy of co-operation which began immediately after the war.

All the allies co-operated in bringing the major war criminals to justice at the Nuremberg Trials, which lasted from November 1945 until October 1946. Throughout Europe the last traces of Nazism were wiped out. Those found guilty of collaborating with the Nazis during the war were brought to trial. Constitutions were set up in the defeated and liberated countries. In Italy, Yugoslavia, Hungary, Bulgaria, and Romania monarchy was abolished and republics established. Most of the constitutions were democratic, and in most of the Western countries, and in Czechoslovakia, Poland, and Hungary in the East, free elections were held.

Territorial adjustments

There were fewer territorial adjustments than after the First World War, and they took much longer to carry into effect. Peace treaties, which were prepared by the foreign ministers of America, Russia, Britain, and France during 1946, were signed with some of the defeated nations – Finland, Hungary, Romania, Bulgaria, and Italy – on 10th February 1947. These treaties, together with other provisional agreements made at the Potsdam Conference, added enormously to the power and territory of Russia. She acquired a belt of land including:



A colossal power station at Duisburg – a city almost totally destroyed during the war

Petsamo and eastern Karelia (from Finland); the Baltic states of Estonia, Latvia, and Lithuania, together with the northern parts of East Prussia (from Germany); a large area of eastern Poland, including Wilno and Lvov; and the Carpathia-Ukraine part of Czechoslovakia, Bessarabia, and northern Bukovina (from Romania).

The boundaries of Poland were considerably enlarged in the west to compensate for her losses to Russia in the east. She acquired southern East Prussia, the former Free Territory of Danzig, eastern Germany up to the Oder-Neisse line, and an area west of the Oder including Stettin.

These adjustments created the need for an unprecedented compulsory exportation of entire populations. To avoid the 'minority' problems which bedevilled European politics between the wars, about 5,000,000 Poles were forcibly evacuated from the east and resettled within the new Polish frontier, while 8,700,000 Germans were similarly transported from the areas now belonging to Poland.

Czechoslovakia was restored to its pre-Munich frontier with Germany, and the 3½ million Germans within the frontier were expelled. Czechoslovakia also gained a small piece of territory from Hungary. Southern Dobruja went from Romania to Bulgaria. Apart from this the boundaries in eastern Europe remained as they had been at the outbreak of war. Italy had to give up her overseas colonies, cede the Dodecanese Islands to Greece and most of Istria to Yugoslavia.

The greatest territorial adjustments were concerned, of course, with Germany. The allies were determined, once and for all, to destroy German militarism, and insisted on nothing less than unconditional surrender. In fact, during the first years after the war Germany ceased to exist. There was no German government, and, in accordance with agreements made at the Potsdam Conference, Germany was divided into zones. America, Britain, and Russia occupied three of these zones, and France was invited to administer a fourth. In 1947 the Saar was separated from Germany and established as an autonomous region with close economic ties with France.

At the end of 1946 few people realised the imminence of the breach between East and West. The foundation of the United Nations (1945) seemed to give an unprecedented opportunity for the Great Powers to work together for common ideals. Unlike the old League of Nations (see page 2753), the United Nations consisted of all the world's most powerful nations, and the chief control was vested in the Security Council. This Council had as permanent members Britain, France, America, China, and the Soviet Union, and as long as these states remained in agreement the United Nations seemed a wonderfully efficient organ of international government. On the other hand, because each member of the Security Council had an absolute veto, it only required one dissident member to paralyse the workings of the Council.

The Cold War: 1947–1953

When it was originally agreed that allied strategy should be for Russia to advance into Germany from the east and the Western allies via Belgium and Holland, it was expected that each allied nation would exercise enormous influence in the countries occupied by its troops. How long this situation would last nobody knew.

It soon became apparent that Russia had no intention of withdrawing her troops. Stalin, the Russian leader, made no move towards disarmament. The limited disarmament programmes in Britain and America were soon halted.

'People's Republics' were established in Hungary, Poland, Bulgaria, Romania, Albania, and Yugoslavia, and Russian control increased in Czechoslovakia. By the summer of 1947 it was clear that the policy of co-operation had broken down. In June General Marshall invited all the European powers to consider their economic problems in conjunction with the United States. The Russians, angry and anxious lest their influence in eastern Europe be undermined by American generosity, refused the invitation and forbade the nations

they controlled to accept. Eastern Europe was thus denied the 'Marshall Aid' which set so many nations on their feet in the impoverished years after the war.

It was also in 1947 that allied co-operation over Germany broke down. Russia refused to support the economic union between France and the Saar, and also denounced any attempt by the allies to reunite zoned Germany. An Iron Curtain descended across Germany and, indeed, all Europe.

Separate currencies were introduced in 'Eastern' and 'Western' Germany in June 1948, and in September the three western zones were united. On 8th May 1949 the Federal Republic of Germany, consisting of the three zones of the Western allies, was established, with its capital at Bonn. On 7th October 1949 the German Democratic Republic, consisting of the Soviet zone, was set up by Russia.

The division of Germany into East and West left Berlin, administered jointly by Russia, America, France, and Britain, some 100 miles inside the 'Democratic Republic'. Suddenly, in June 1948, the Russians closed the land route to Berlin. But the Western powers were determined not to lose contact with Berlin. The result was a massive airlift in which food and supplies were taken to the West Berliners at a rate of one plane-load every four minutes. During the summer tension mounted. It seemed as if a new war was inevitable. Then, in May 1949, the Communists abandoned the blockade, and an uneasy truce was established.

By 1949 the Cold War was the dominating problem in world politics. In that year the Communists triumphed when Russian-aided Mao Tse-tung drove Chiang Kai-shek off the mainland into Formosa, and took control of China. In the Western nations Communists were driven from official posts, and continual propaganda broadcasts were delivered on both sides of the Iron Curtain. In eastern Europe the Communists took complete control by purging (abolishing or destroying) all other parties. In Czechoslovakia a Communist government had seized power by a *coup d'état* in February 1948.

Further areas of conflict developed. Russia demanded reparations from Austria, and vetoed Western proposals for both Austria and Italy to join the United Nations. The Western powers denounced the persecution of the Church in certain Communist countries. A three-year civil war in Greece (1947–1949) resulted in defeat for the Communist rebels supported by Russia. Britain and the United States had aided the anti-Communists. This set the pattern for future conflicts. In the early 1950s the French unsuccessfully tried to prevent the Communists establishing themselves in Indo-China, while between 1950 and 1953 a major war was fought, largely by the Americans, to prevent Communist control of Korea. They partially succeeded, and in 1953 Korea was partitioned between the Communists in the north and the anti-Communists in the south.

The Cold War developed under the shadow of the atom bomb – a bomb many thousand times more powerful than any 'conventional' bomb dropped in the Second World War. The Americans were the first to have the atom bomb (1945), but by 1949 atomic explosions were being detected in Russia. By 1952 Britain had the bomb, and in the following year both America and Russia were in possession of an incomparably greater weapon than even the atom bomb – the hydrogen bomb.

Meanwhile, although the Second World War had only recently ended, the Western powers had bound themselves closely together in a military alliance. On 17th March 1948 the Brussels Treaty was signed between Britain, France, Belgium, Luxembourg, and the Netherlands. On 4th April 1949 this pact for mutual defence was superseded by the North Atlantic Treaty Organisation, whose founder members were America, the Brussels Treaty powers, Denmark, Norway, Portugal, Iceland, Canada, and Italy.

The Eastern nations were similarly organised. In 1947 the Communist information service, *Cominform*, was established to bring the Communist parties of Europe closer together. In 1955 a full-scale military alliance, the Warsaw Pact, came into being as the Communist equivalent of N A T O.

1953 is generally accepted as marking the end of the Cold War. In that year Stalin died and the Korean war ended. Realising that the fantastic power of nuclear weapons would make another war a militarily useless proposition, the leaders of Russia and the West have sought a policy of 'peaceful coexistence'. But the Iron Curtain remains and appears as strong and rigid as ever. An unbroken chain of Communist states still stretches across Europe. At one end is Finland, precariously maintaining her independence; at the other is Yugoslavia which, though Communist, has managed to stay outside the orbit of Russian 'satellites'. Many danger points, notably the Berlin situation, remain as potential threats to world peace. Into what pattern Europe will settle down after the terrible shaking-up of the Second World War and its aftermath is still far from clear.

The great hydroelectric plant at Volgograd in Russia, built since the war

MEXICO: economy

IMMEDIATELY south of the United States lies Mexico, a large, colourful country with vast forests, imposing mountain ranges, and picturesque scenery. Mexico is the third largest Latin American country after Brazil and Argentina, and only Brazil has a larger population.

The population of Mexico is growing very rapidly. It was under 20 million in 1940, and in 1962 was estimated at 37¼ million. It includes a large proportion of people of Indian descent, as well as many of Spanish origin (see page 2264).

Many of the inhabitants of Mexico live on the central plateau, which has the capital, Mexico City, at its heart. The Federal District (Mexico City and its suburbs) has a population of almost 5 million – the second largest in the Western Hemisphere. It is a modern, spacious, and prosperous city, and it is the second highest capital in the world (see page 2830).

SOME OF THE PRODUCTS OF MEXICAN AGRICULTURE

harvesting guano, which is used as fertiliser

a primitive method of threshing corn

cereus giganteus – a characteristic Mexican cactus

cotton ready for harvesting

oxen used to work in the fields

Slums coexist with luxury flats in the towns, while in the country many farmers glean only a bare living from the soil. And only about one-half of all Mexicans over the age of 10 can read and write.

Striking variations

Mexico is a land of great variety. There are large areas of desert, vast forests, and fertile, well-watered plains. Great mountain ranges cross Mexico, giving widely differing climates. Spectacular, snow-covered volcanic peaks dominate much of the landscape of the central region. Orizaba is 18,700 feet high; Popocatepetl, 17,887 feet; and Ixtacihuatl, 17,342 feet.

Contrasts exist not only in rainfall, temperature, and scenery but among the people: between those of Indian and of European stock, and between rich and poor. For Mexico is a poor country, and despite great progress in recent decades much of her population still lives in conditions of extreme poverty and ignorance.

DIVISION OF LAND IN MEXICO

① Grazing land. About 80 million acres. ② Desert land. About 42 million acres. ③ Forests. About 50 million acres. ④ Arable land. About 15 million acres

Agriculture

Like most of the other Latin American countries, Mexico is essentially an agricultural country, and agriculture is the basis of her economy. About two-thirds of the population work on the land, and nearly half the farmers live in the central region. Much of the farming land is divided into communal holdings called *ejidos*. The main crop is maize, and over one-half of the total cultivated area of Mexico is used for growing it. Wheat production, however, is increasing rapidly, and has expanded three-fold since 1950 as a result of the introduction of modern methods of planting and harvesting.

Fruit, vegetables, dairy-farming, and sugar production are all increasing as the economy becomes more prosperous, but the greatest gains have been in the output of cotton and coffee. Cotton production has grown seven-fold since 1945, while coffee production has more than doubled. Mexico's forests hold vast resources of many types of wood, including mahogany, rosewood, and ebony.

One of the main agricultural problems facing Mexico today is that of increasing the area that can be farmed. With so much territory consisting of desert, semi-desert, and mountain slopes, the area under cultivation is limited, and, moreover, soil erosion is becoming serious in many areas. As a result, the government has encouraged irrigation schemes, especially in cotton-growing regions, and Mexico now has more irrigated land than anywhere else in Latin America.

Modern harvesting methods have contributed to the great increase in Mexico's wheat production

Trade

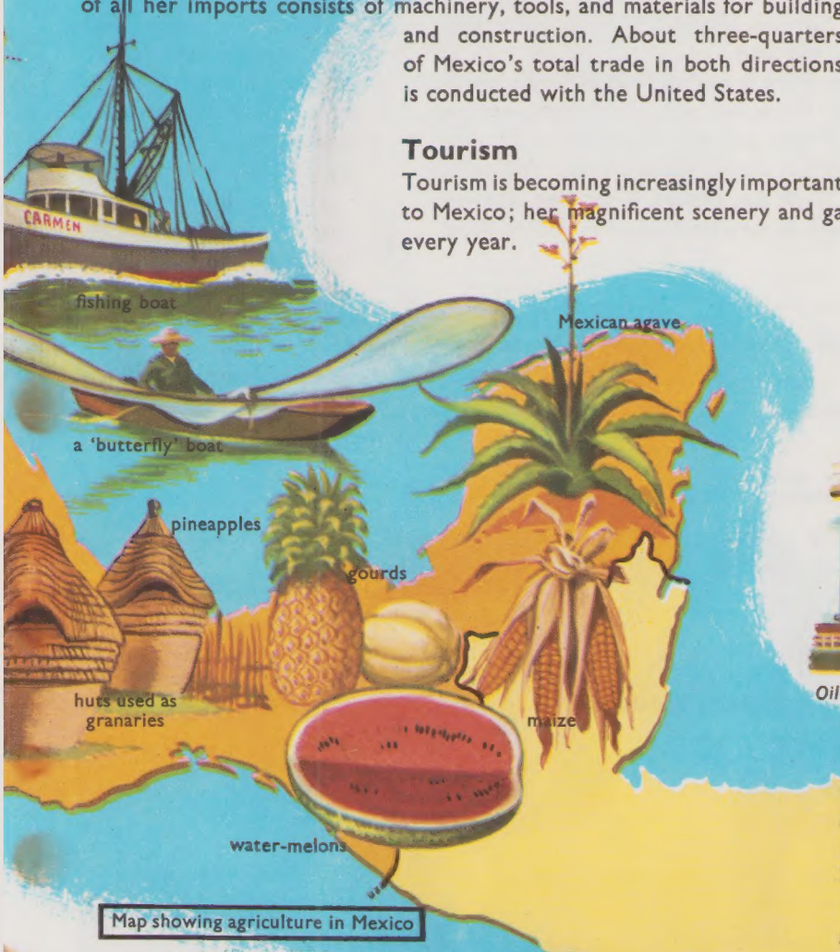
Most countries of Latin America depend on one major export to earn the money to pay for the imports they need. Mexico is a notable exception, for she exports a variety of products, and their value is increasing continually.

Mexico's principal product is raw cotton, and this forms about one-third of her total exports. She is now the second largest exporter of cotton in the world after the United States, and the third largest exporter of coffee after two other Latin American countries, Brazil and Colombia. About one-quarter of Mexico's exports consists of minerals, which provide a major source of revenue. The most important of these minerals are copper, petroleum, and lead, and Mexico is also the leading exporter of silver.

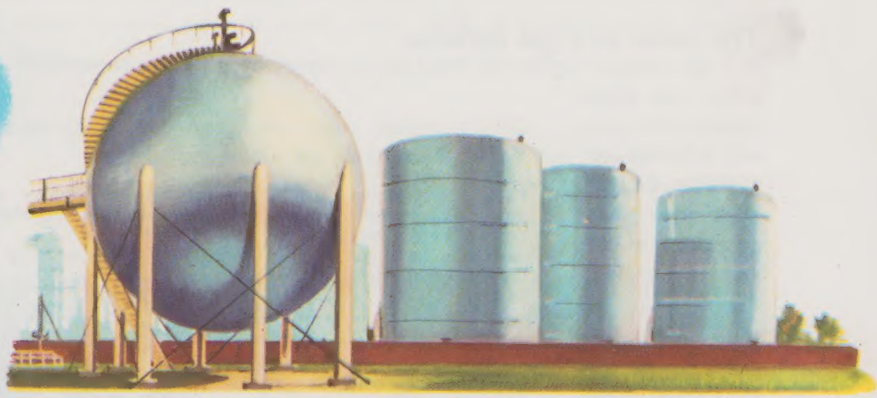
Mexico's principal imports are manufactured goods. Indeed, one-half of all her imports consists of machinery, tools, and materials for building and construction. About three-quarters of Mexico's total trade in both directions is conducted with the United States.

Tourism

Tourism is becoming increasingly important to Mexico; her magnificent scenery and gay cities attract thousands of visitors – mainly from North America – every year.



Map showing agriculture in Mexico



Oil-refineries, such as this one at Minatitlán, symbolise Mexico's industrial progress

Industry

Manufacturing is not as important in the Mexican economy as either agriculture or mining. But, nevertheless, it is growing quickly, and great strides forward have been made. Textiles are the chief industrial product, the major centres of production being in the central region. Steel output is improving, and the industry doubled in size between 1951 and 1957. Cement, chemicals, and the paper industry are all growing, and so is the production of machinery, tools, electrical equipment, and fertilisers.

There has been an enormous increase in electricity generating recently: output has increased by 700 per cent since the early 1950s.

Minerals

Mexico possesses great mineral resources, though the output of precious metals (gold and silver) has been declining steadily. Monclova and Monterrey in the north are the main centres of the expanding Mexican steel industry. Monterrey produces nearly 60 per cent of the country's total steel output, and it is also the main lead-smelting centre in Mexico.

Other minerals besides iron ore which are mined in northern Mexico include copper, coal, bismuth, antimony, and mercury. Zinc and manganese are also being produced in increasing quantities, and sulphur output has developed so rapidly that Mexico is now the second largest producer in the world. Uranium has been discovered recently in several provinces. Petroleum output is expanding steadily, and now provides the main source of industrial power in Mexico.

FACTS AND FIGURES

Area	760,373 sq miles
Population (1960)	34,923,129
Railways	15,000 miles
Roads	22,000 miles
Major airports	38
Main ports	Vera Cruz and Tampico
Currency	1 peso=100 centavos

CHIEF TOWNS

Mexico City (and suburbs)	4,871,000
Guadalajara	734,346
Monterrey	596,939

GAS TURBINES

A GAS turbine is a heat engine. Its purpose is to convert the heat energy of fuels such as paraffin and diesel oil into mechanical energy capable of doing useful work. Though these engines appear to be very complex, the principle behind them is a straightforward one. It is simply that when a gas (in this case air) is heated it expands, and thus occupies more space.

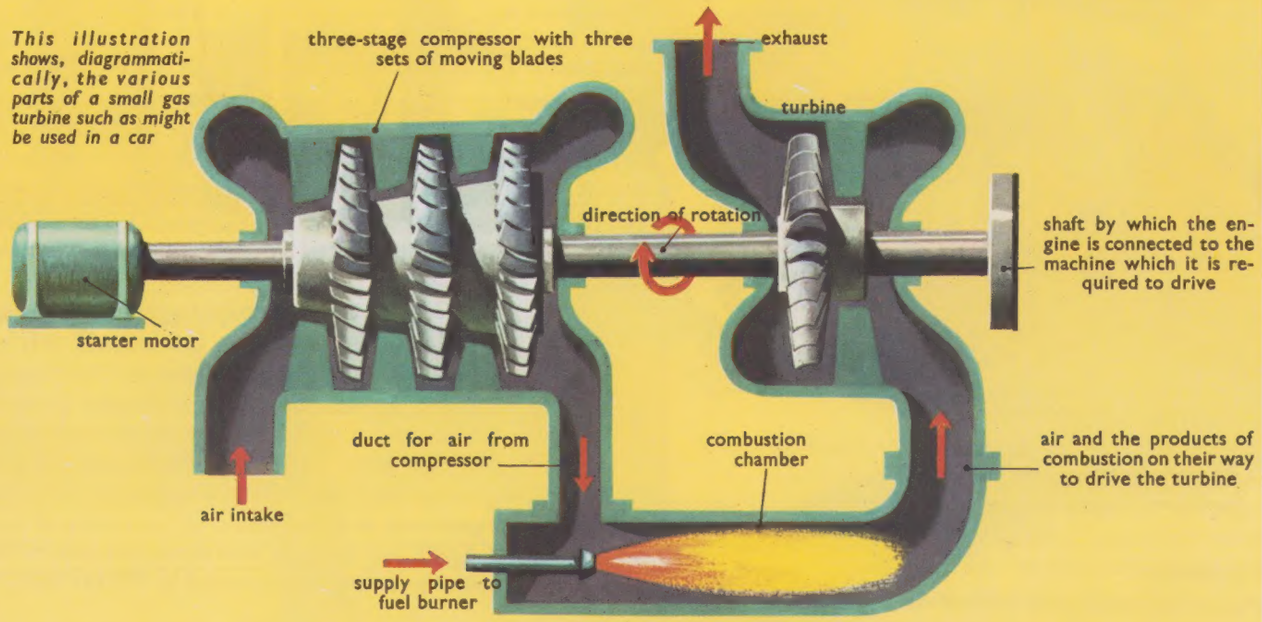
How a gas turbine works

When we are trying to understand how a gas turbine works it is helpful if we imagine a piece of drain pipe about 3 feet long. Within one end of this pipe, the 'front' end, a small fan is so arranged that it draws in air and blows it along the pipe's interior. At the other end, the 'rear' end, a similar fan is arranged pointing in the same direction. It is easy to see that when the front fan is rotated the air which is pushed into the pipe can escape only by passing the rear fan. As it escapes this air will turn the blades of the rear fan with a force which is equal to that used by the front fan in pushing the air into the pipe.

Next, it is necessary to imagine that in the middle part of the pipe there is a small hole through which a little jet of fuel is pumped. When the jet is lit the flame heats the air inside the pipe, and in consequence the air expands. To escape from the pipe this larger volume of air must flow past the rear fan more quickly than the smaller volume of cold air, and thus the blades of the rear fan are turned more rapidly. The work which the rear fan can now do thus *exceeds* that needed to turn the front fan. Indeed, if the two fans are mounted on a single shaft, the power obtained from the rear one is enough to turn the front one and yet leave sufficient power in the shaft to do some form of work.

The parts of a gas turbine

In a gas turbine engine the front fan is represented by the compressor. This is much more complex than a fan, and often consists of several different sets of blades, designed to draw great quantities of air into the engine. This air passes into the *combustion chamber*, where it is heated by the paraffin flame. It increases in volume and escapes past the *turbine*, the rear fan, turning it at great speed. The turbine turns the compressor, which consequently draws in more air.


three-stage compressor with three sets of moving blades
exhaust
turbine
direction of rotation
shaft by which the engine is connected to the machine which it is required to drive
starter motor
duct for air from compressor
combustion chamber
air and the products of combustion on their way to drive the turbine
air intake
supply pipe to fuel burner

This illustration shows, diagrammatically, the various parts of a small gas turbine such as might be used in a car

THE USES OF GAS TURBINES

The most important application of gas turbine engines at the present time is, undoubtedly, their use as a source of power for aircraft. They are also used, however, for several other kinds of transport, including hovercraft, hydrofoil marine craft, and experimental motor cars.

The use of gas turbines in remote-controlled power stations which provide electricity at peak demand is likely to become increasingly important.

GAS TURBINES IN THE AIR

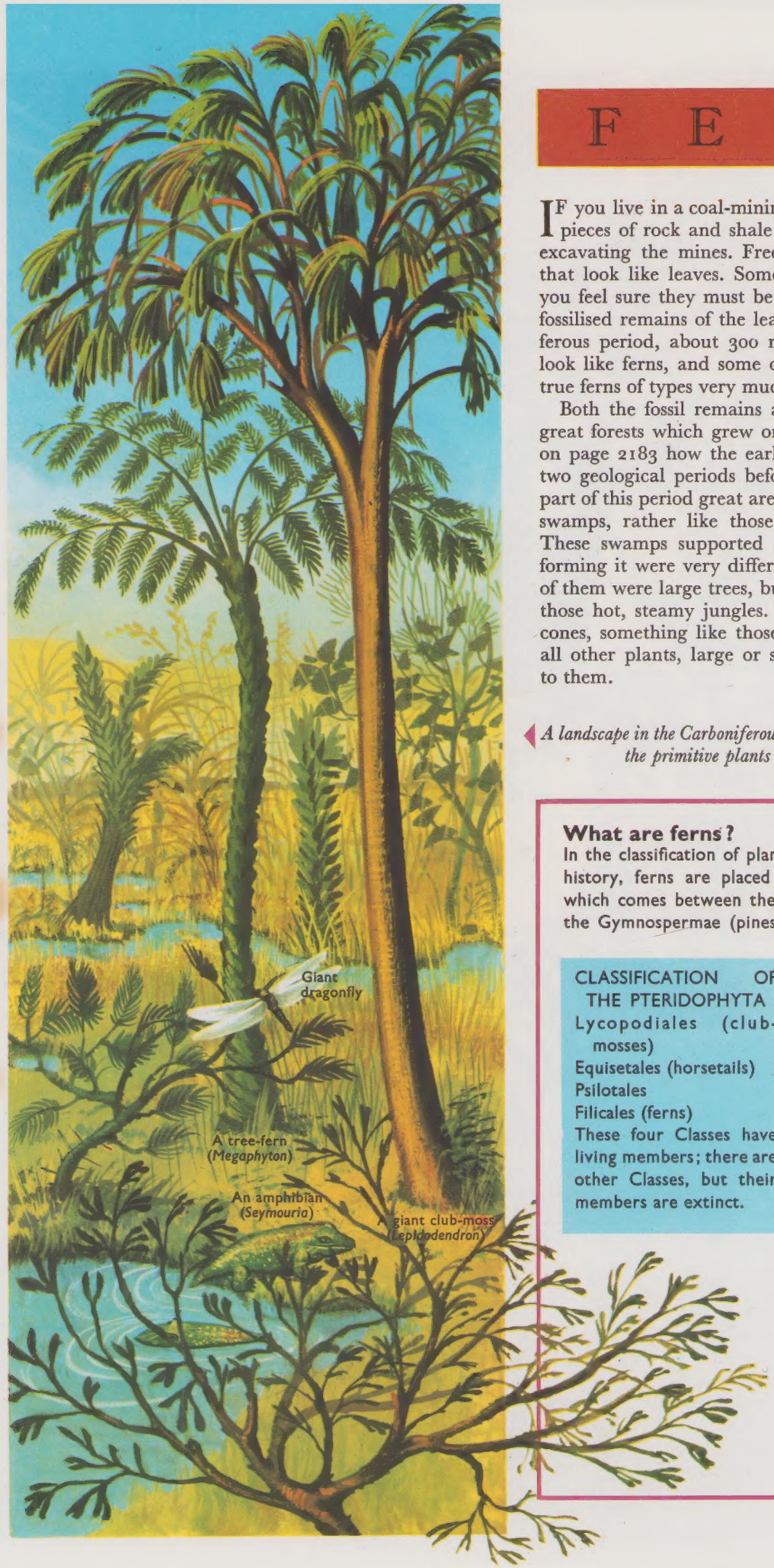
No development in engineering has had such far-reaching effects upon aeronautics as the invention of the gas turbine engine. These engines are lighter than piston engines of equivalent horsepower, and, as they use paraffin instead of petrol, the fire hazard is greatly reduced. They have enabled manufacturers of aero-engines to dispense with propellers, and, in consequence of this and the great thrust which gas turbines develop, they have made possible flight at supersonic speeds.

In some gas turbine engines the power in the shaft is used, by means of a train of gears, to drive a conventional propeller. Such engines are called *turbo-prop* engines. In other engines, however, almost all of the power in the shaft is used to work a large compressor. A very great volume of air is consequently forced through the engine, and as it escapes backwards in a forceful jet it propels the aircraft forwards. Engines of this type are called *turbo-jet* engines, and it is these that are used in aircraft with supersonic capabilities.

FERNS

IF you live in a coal-mining district it is well worth examining the pieces of rock and shale brought to the surface in the course of excavating the mines. Frequently there are black marks on them that look like leaves. Sometimes the resemblance is so exact that you feel sure they must be leaves, and you are right; they are the fossilised remains of the leaves of plants that lived in the Carboniferous period, about 300 million years ago. Many of these fossils look like ferns, and some of them (though by no means all) were true ferns of types very much like those alive today.

Both the fossil remains and the coal itself are relics of the first great forests which grew on the earth. We have already described on page 2183 how the earliest land plants came into being in the two geological periods before the Carboniferous. During the later part of this period great areas of the earth were occupied by tropical swamps, rather like those at the mouth of the Amazon today. These swamps supported a luxuriant vegetation, but the plants forming it were very different from those of modern forests. Many of them were large trees, but there was no such thing as a flower in those hot, steamy jungles. Such plants as had seeds bore them in cones, something like those of the pines and firs of today. Almost all other plants, large or small, were ferns or forms closely allied to them.



A landscape in the Carboniferous period, about 300 million years ago. Many of the primitive plants that made up the forests were ferns

What are ferns?

In the classification of plants, which is based on their evolutionary history, ferns are placed in a Division called the Pteridophyta, which comes between the Bryophyta (mosses and liverworts) and the Gymnospermae (pines and other conifers). The pteridophytes differ from the bryophytes in having vascular tissue, consisting of tubes for conveying water from one part of the plant to another. They differ from the gymnosperms and angiosperms (flowering plants) mainly in their method of reproduction. The pteridophytes, like the bryophytes, reproduce by means of spores, which are very small and never consist of more than a few cells. Gymnosperms and angiosperms reproduce by seeds, which are usually much larger and include a food-store and an embryo. As we shall see, ferns give a clue to their bryophyte ancestry by going through a stage almost exactly like that of the plant-body, or *thallus*, of a liverwort. Ferns are by far the most numerous of the pteridophytes, and are distinguished by their large leaves and by the fact that the spores are borne on the leaves and not on special cone-like structures.

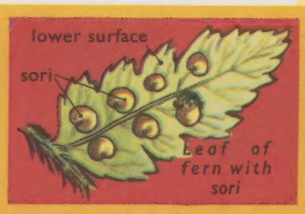
CLASSIFICATION OF THE PTERIDOPHYTA

Lycopodiales (club-mosses)
Equisetales (horsetails)
Psilotales
Filicales (ferns)

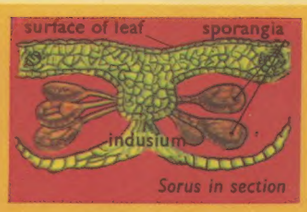
These four Classes have living members; there are other Classes, but their members are extinct.

HOW FERNS REPRODUCE

Ferns reproduce in much the same way as mosses (see page 698). A small, active cell swims in a film of water and fertilises another cell, from which a spore-bearing structure grows. This develops to form the whole plant, instead of being just a part of it, as in mosses.

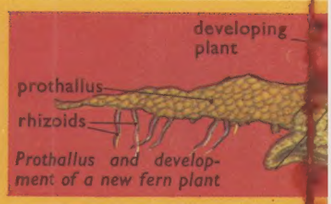


① Small, rounded bodies called *sori* grow on the underside of the leaf, usually arranged on either side of the midrib.



② A single sorus in cross-section. Under a cover, the *indusium*, are a number of tiny, club-shaped structures called *sporangia*.

③ A single sporangium, greatly enlarged. When ripe it splits and releases numerous spores.



④ Falling in a damp place, a spore germinates and grows into a small, green *prothallus*. This produces active 'male' cells and

Over 6,000 species of ferns

Ferns are found all over the world in tropical and temperate regions, and are specially numerous in the wetter parts of the tropics. They need moist surroundings because their reproductive processes can only take place in the presence of water. Most of them have feather-shaped 'bipinnate' leaves and are quite small plants, but in the tropics tree-ferns grow to over 20 feet in height. Some typical ferns are shown on these two pages.

Male fern (*Dryopteris filix-mas*). Apart from bracken (*Pteridium aquilinum*) this is the most common species of fern in Britain. It grows in shady woods, and its leaves may be more than a yard long.

Lady fern (*Athyrium filix-femina*). This is a more graceful and delicate plant than the male fern, and the early botanists thought that the two were the male and female of the same species. It grows in similar situations and is hardly less common than the male fern. Many ornamental varieties of the Lady fern are cultivated.

Common polypody (*Polypodium vulgare*). This very common fern is easily recognised by its smoothly rounded leaflets. It has a thick, creeping rhizome and is usually found growing on tree-stumps or in old walls rather than on the ground.

Hartstongue (*Phyllitis scolopendrium*). You might not recognise this as a fern, for its leaves are not divided into leaflets. A look at the underside of the leaf, however, immediately reveals what it is, for the sori (obliquely placed brown ridges) are very noticeable. It is common on walls and banks, especially in western Britain.

Tree-fern (*Alsophila crinita*). These beautiful plants are found in the tropics, usually in hill regions with high rainfall. This species is a native of Ceylon.

Maidenhair fern (*Adiantum capillus-veneris*). This fern is found growing in the western part of Britain, and several similar species are cultivated in greenhouses. The stems are black and wiry, and the leaflets are quite separate from one another. The sporangia are borne under inrolled portions of the margins of the leaflets.

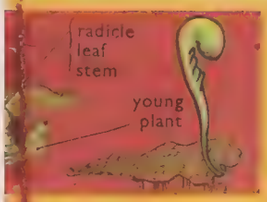
Platycerium bifurcatum. This is a remarkable fern which grows as an epiphyte (see page 2497). It has two different kinds of leaves, one of which bears sori while the other does not. Species of *Platycerium* are found in Africa and Australia.

Leaf of a male fern

Leaf of a Lady fern

Leaf of a polypody

Leaves of harts-tongue fern



The new fern plant

inactive 'female' cells. A leaf grows from the fertilised female cell.

⑤ Roots and more leaves are added, and so a new fern plant comes into being, which will develop sori and sporangia.

Leaflets of maiden-hair fern

A tree-fern from Ceylon

Platycerium bifurcatum

OTHER KINDS OF PTERIDOPHYTES

Although most living pteridophytes are ferns, there are two other Classes with fewer species. Of these, horsetails (Equisetales) and club-mosses (Lycopodiales) are the most familiar. Psilotales are very primitive tropical plants; there are only four species. All these plants reproduce by spores.

Horsetail (*Equisetum arvense*). The spores on this common plant are borne in cones, which appear in spring. The jointed stems which come up later never bear spores.

Club-moss (*Lycopodium*). Several species of club-moss are found in Britain, mainly on peaty moors in the north and west. They are larger and more robust than mosses.

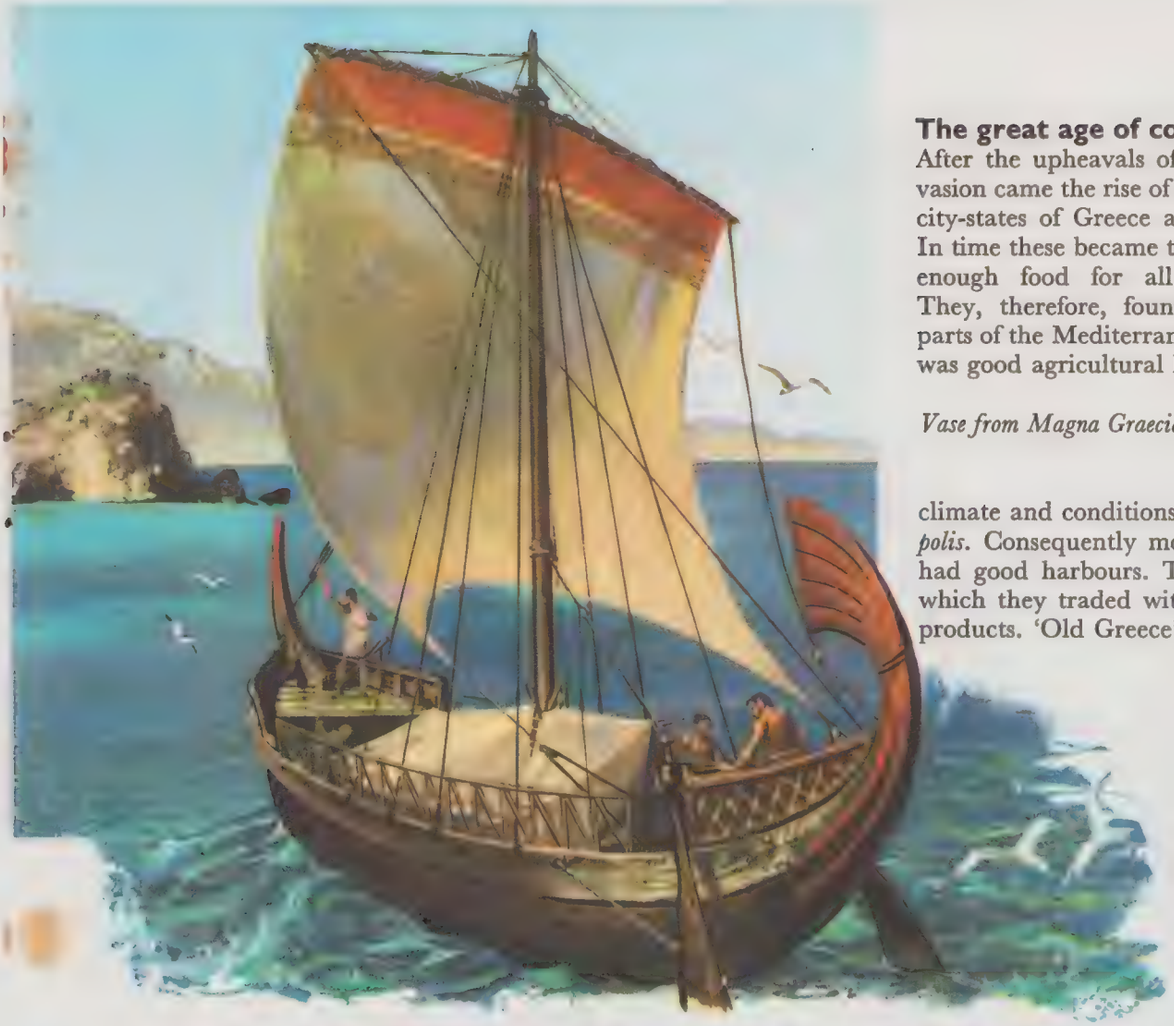
Ships from the mêtropolis *arrive on the coast of southern Italy where a new city-state is rising*

MAGNA GRAECIA AND GREEK COLONISATION

IN the harbour of an Ancient Greek city two ships are about to set sail. A large crowd of citizens has gathered to see them off, and to say goodbye to the passengers, some of whom they may never see again. For these are emigrants: young, enterprising, and drawn from all classes of society, and they are seeking their fortune in a new land beyond the seas.

The government of the city has already consulted the great oracle of Apollo at Delphi. The oracle has approved the proposed site for the colony, and the man chosen as *oikistés*. He will lead the expedition, and will take with him the sacred fire from the hearth of the mother-city (*mêtropolis*).

The first group of settlers includes soldiers, in case there is



opposition from the native inhabitants. Other groups will follow later. The settlement (in Greek, *apoikia*, a 'home from home') will be a new city-state. Right from its foundation (unlike a Roman or modern colony) it will be politically independent of its *mêtropolis*, though commercial, cultural, and particularly religious ties will probably remain strong. The colonists cannot return to the *mêtropolis* as citizens unless the colony as a whole is a failure.

For several centuries such scenes were not uncommon in Greece. Why?

Head of a young man (6th century B C) from Acragas

The first great migrations

There were two great periods of Greek migrations: the first about 1100–900 B C, the second about 800–550 B C.

Less than a century after the fall of Troy in about 1240 B C (see page 1521) the Dorians, the last wave of Greek-speaking peoples, conquered most of Greece except Athens and Attica. The earlier Greek peoples remained as their subjects or slaves, or fled across the seas. The Aeolians of northern Greece settled in Thrace, on the north-west coast of Asia Minor, and in the islands of Tenedos and Lesbos. The Ionians moved first into Attica, which for a time must have resembled a vast refugee transit camp. They then moved to the south-west coast of Asia Minor and the islands of Chios and Samos. (Some of the Dorians also settled on the south coast of Asia Minor, and in Rhodes.) From this time until the rise of the Roman state these areas must be considered part of Greece.

The great age of colonisation

After the upheavals of the Dorian invasion came the rise of the independent city-states of Greece and Asia Minor. In time these became too large to grow enough food for all their citizens. They, therefore, founded colonies in parts of the Mediterranean where there was good agricultural land, and where

Vase from Magna Graecia – now in Taranto Museum

climate and conditions were similar to those of the *mêtropolis*. Consequently most *apoikiai* were on the coast and had good harbours. They often had a surplus of food, which they traded with 'old Greece' in return for local products. 'Old Greece', now no longer entirely dependent on local food production, could therefore support a larger population, so that there was less need for further colonisation. This was one reason for the virtual end of new colonisation by about 550 B C.

A few colonies were founded for trade, particularly those established by Corinth; and markets for Greek traders were established at Naucratis in Egypt and Poseidium in Syria.

Greek colonies were far more widespread around the Mediterranean and the Black Sea than is generally realised. In the 5th and 4th centuries B C Athens' food supplies, for example, depended largely on the wheat and fish which she imported from the Black Sea area. Some Greek colonies are still important cities today, notably Byzantium (Istanbul) and Massilia (Marseilles).

SICILY AND MAGNA GRAECIA

Acragas (Agrigento) – remains of the Doric temple of Hera (5th century B C)

The most famous and powerful of all the Greek colonies were in Sicily and southern Italy, which even came to be called Magna Graecia (Great Greece). Syracuse in particular was not only powerful; it was also, for a long time, second only to Athens as a centre of learning and art. Other important colonies included Neapolis (Naples), Cumae, Taras (Taranto), Sybaris (a by-word for the luxurious wealth of its inhabitants), Croton and Rhegium on the mainland, and Messana, Leontini, Gela, Acragas (Agrigento), and Selinus in Sicily.

JAPAN: physical

HAVE you ever looked at a map of the world and compared the positions of the British Isles and Japan? Both are groups of small islands lying just off the continental land mass of Europe and Asia respectively. But there the resemblance ends. For while much of the British Isles consists of plains and rolling downlands, Japan is a country of high mountains and volcanoes, with only tiny plains and valleys which are scattered all over the islands.

Japan is made up of four main islands – Hokkaido, Honshu, Shikoku, and Kyushu – and more than 3,300 smaller islands. They all lie close to one another and are arranged in the form of a chain or archipelago. In area the islands total 140,680·9 square miles and they support a population of about 95 million (1963 estimate); but at least three-quarters of the land is too mountainous for cultivation.

In these difficult circumstances every square foot of gently sloping land must be used; the hillsides are terraced and the fields go down to within a few feet of the breakers on the beach. These limited natural resources, however, have not prevented the growth of Japan into a large and powerful nation.

A series of mountain chains

The mountains of the four main islands are all rugged in character and dissected by steep-sided valleys. The hills rise to over 10,000 feet in the central part of Honshu (Fujiyama, 12,389 feet), while on the other islands they barely reach 5,000 feet. Compared with the hundreds of millions of years of earth history the mountains of Japan are young; the rocks were formed deep beneath the sea by the slow accumulation of sediment. Earth movements have compressed and folded these sediments into rocks, and thrust them up high above the sea as mountains. We know the rocks are young because of the fossil remains of sea creatures within them; we know the hills are young because of their sharp, concave slopes and knife-edged ridges, showing that they have only recently been affected by the processes of erosion.

Facts and figures
Total area: 140,680·9 square miles
Four main islands: Hokkaido, Honshu, Shikoku, and Kyushu
Highest mountain: Fujiyama, 12,389 ft
Most active volcano: Asama, about 8,300 ft
Land use (percentage of total):
Arable land: 13·7%
Permanent meadow 3·8%
Forest and wood: 60·9%
Waste and city: 21·6%
Among the most important mineral resources are: coal, zinc, and copper.

Preparing the fields for growing rice, Japan's staple food

Knife-edged ridges and steep slopes of the 'Japanese Alps' in Honshu

Looking over Lake Shoj in spring-time. The volcano Fujiyama, the highest mountain in Japan, rises majestically over the lake

Volcanoes

Variety and contrast are given to the Japanese landscape by the scores of volcanic cones, together with their associated lava and ash plateaux. Although they are seen throughout the Japanese island arc, volcanoes are concentrated in some areas and absent in others; they are particularly numerous in Hokkaido, the northern part of Honshu, and the central part of Honshu (just west of Tokyo). One of the most famous and beautiful is Mount Fuji, or Fujiyama, which was last active in 1707. About 60 of the volcanoes are classed as active – Japan is, in fact, one of the areas of greatest volcanic activity.

Associated with this volcanic activity are earth tremors and mineral springs. A feature of life in Japan is the frequency of earthquakes, which often have tragic consequences. There are some four to five tremors a day; most cannot be felt, but Tokyo experiences a sensible tremor every three or four days. The buildings are either designed to resist this, in reinforced steel and concrete, or are built of flimsy paper and wood.

Terraced fields near Hiroshima

Coasts and rivers

The rivers of Japan are short and swift-flowing; they are of little use for navigation, but many are diverted and controlled for irrigation and for hydroelectric power. As these rivers descend on their steep courses from the mountains to the sea, they carry away a great amount of rock material. When the gradient lessens near the coast much of this debris is deposited as alluvial terraces and fans. The soils of the tiny coastal lowlands are usually of this alluvial material. Separating these lowlands are rocky and irregular coasts where the mountains reach almost to the sea.

Climate

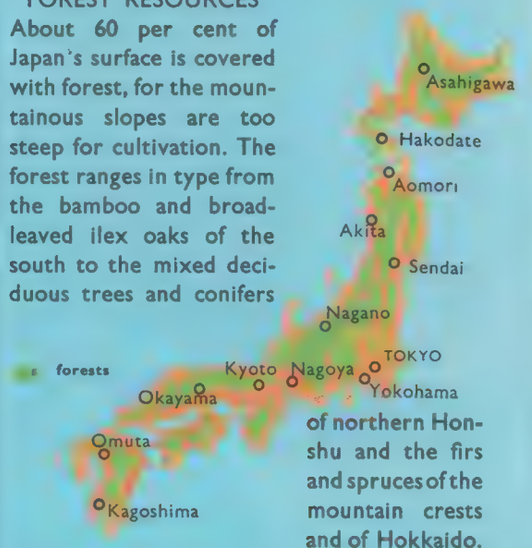
Asia dominates the islands' climate. In winter it is the centre of a mass of cold air which spreads east to affect Japan from December to March. As the cold air passes over the sea it picks up enough moisture to bring Japan snow; in the western mountains the annual snowfall is 30 inches. Winter temperatures are generally around freezing point, while in the extreme north and in the mountains it is considerably colder.

In summer Asia is the focus of warm, damp air moving in from the oceans in the south and the west; these 'monsoons' affect Japan slightly from May to September. The rains, some of which are brought by typhoons from the south, fall in June and early September. June temperatures range between 60°F in the north and 80° in the south. Rainfall varies with the landscape, and is usually between 50 and 80 inches each year.

Two ocean currents, a cold one from the north called the Oyashio Current, and a warm one from the south, the Kuroshio Current, influence Japan's climate. The warm current moderates the weather along all the coasts except the east coast of Hokkaido and north Honshu, where the Oyashio Current brings lower summer temperatures and fog.

FOREST RESOURCES

About 60 per cent of Japan's surface is covered with forest, for the mountainous slopes are too steep for cultivation. The forest ranges in type from the bamboo and broad-leaved ilex oaks of the south to the mixed deciduous trees and conifers of northern Honshu and the firs and spruces of the mountain crests and of Hokkaido. The forest supplies the pulp and furniture industries; it is also any traveller's most lasting impression of the country.



A rocky and picturesque part of the Japanese Pacific coast near Yaizu

THE COTSWOLDS

Evening in the heart of the Cotswolds. The rolling open grassland, studded with trees, is typical of this lovely region

WHEN the first Neolithic invaders came to England they settled on high hills, where the soil drained quickly and was light enough to be cultivated with their primitive ploughs. One range of hills which provided them with the conditions they sought was the Cotswolds, a chain of limestone hills which stretch north-east for about 60 miles from Bath (see page 1510), forming a watershed between the Severn to the north-west and the upper drainage basin of the Thames to the south-east. They vary between 6 and 30 miles in width, and in height they are generally between 400 and 800 feet, though Cleeve Cloud, the highest point, is 1,070 feet above sea-level.

Early inhabitants

Many curious, pear-shaped mounds are found in the Cotswold hills. These long barrows, as they are called, are the communal tombs of the Neolithic inhabitants. Sometimes all that remains of such a barrow is a group of standing stones, or megaliths, like the Rollright stones near Chipping Campden in the north of the Cotswolds. This group consists of a single isolated stone, the King's Stone; a circle of about 70 stones known as the King's Men; and a group of five stones known as the Whispering Knights. According to legend, a witch turned the king and his men into stones and herself into an elder tree, and every night at midnight the stones go down to a nearby stream to drink.

The first Bronze Age people to live in the Cotswolds were known as Beaker Folk, from a kind of pot they used. They were buried singly in a crouching position, with daggers, bows and arrows, ornaments, and beakers placed around them. These graves form the round barrows which are also found on the hills.

Perhaps the most striking reminder of early inhabitants in the Cotswolds is the presence of Iron Age camps encircling many of the hilltops. These are now shown by banks and ditches, which thousands of years have not been able to obliterate.

Roman prosperity

When the Romans came to England they too settled in the Cotswolds. Three of their great roads – the Fosse Way, Ermine Street, and Akeman Street – crossed at Cirencester, which became the second largest town in England. The local farmers prospered, and although the large landowners were mostly British, they built themselves villas on the Roman pattern. Several of these have been found near Cirencester; they were luxurious, with beautiful mosaics, central heating, and plastered and decorated walls. These villas consisted of the house of the owner, dwellings for the workers, and farm buildings. One wing of the famous villa at Chedworth, now owned by the National Trust, was used for processing wool cloth. At this time sheep were grazed on the Cotswolds, and the wool and cloth of the area were exported.

These villas were most prosperous in the 4th century, and declined when the Romans left Britain and Saxons took over the region. The name Cotswolds comes from two Anglo-Saxon words: *cote*, a sheepfold, and *wold* or *weald*, open, uncultivated land. One Saxon tribe, the Hwicce, gave their name to Wychwood, a forest which once stretched over the high ground between the Evenlode and Windrush valleys and was a royal chase. In 1862 Queen Victoria sold it and now only a small fragment near Charlbury remains. The rest has been cut down and is now agricultural land.

The age of wool

The most prosperous period in the history of the Cotswolds was the Middle Ages, when the wool trade played a vital part in England's economy (see page 2596), and the Cotswolds played a vital part in the wool trade. The Cotswold sheep, known as 'Cotswold Lions' and famous for their long and silky fleeces, were grazed on the hills and brought wealth to their owners. In the 15th century the chief meeting-place in the Cotswolds for wool merchants was Northleach, closely rivalled by Chipping Campden. The wealthy merchants of the region used some of their money to build manor houses and churches in the local stone, and many of the tombs and brasses show the effigies of merchants with one foot resting on a wool sack and the other on a sheep.

When the wool trade declined the Cotswolds became less prosperous, for little industry came to take its place. Today almost the only industries in the district are blanket-making at Witney and cloth-making and engineering around Stroud, and most of the people earn their living by farming, raising crops as well as animals. A further source of revenue is the hoards of tourists who come to the Cotswolds from all parts of England, and from overseas.

The Cotswolds today

What do these tourists come to see? The main attractions are the lovely villages and towns, and surely no other district in England has such charming place-names: Stow-on-the-Wold, Bourton-on-the-Water, Moreton-in-the-Marsh, Shipton-under-Wychwood, Weston-sub-Edge – the list seems endless. Sometimes several villages along the course of a stream or river will all bear the stream's name – for example, Down Ampney, Ampney St Mary, and Ampney Crucis; or Duntisborne Rouse, Middle Duntisborne, Duntisborne Leer, and Abbot's Duntisborne.

Many lovely manor houses are found in the Cotswolds, like 16th-century Frocester, with its magnificent late 13th-century tithe-barn, the largest in England. There is also Sudeley Castle, which originated in the 12th century, was rebuilt on a grand scale in the 15th century, was visited by Catherine of Aragon and Anne Boleyn, and was the home of Catherine Parr after she married Lord Seymour. By the early 19th century it had deteriorated into an alehouse, but has now been restored as a magnificent manor house.

The largest town in the Cotswolds is Cirencester – which is pronounced 'Cisester', 'Cisiter', 'Syren', or as it is spelt. It declined after the Romans left, but became a flourishing wool town in the Middle Ages after the founding of the abbey in the 12th century. As late as 1700 Defoe wrote that the quantity of wool sold there was almost incredible, and imposing houses like those in Coxwell Street were built by wealthy wool merchants. All that remains of the abbey is a gateway, but the parish church dominates the town, with its 14th-century tower and magnificent south porch.

Although Cirencester is the only town of any size in the Cotswolds, there are several other charming small towns. Burford, on the river Windrush, has a lovely church (with a spire and tower) inside which are many brasses and monuments. Further up the Windrush is Bourton-on-the-Water, which is sometimes called the Venice of the Cotswolds, since the river flows right through it, crossed by several low and graceful bridges. Chipping Norton, right in the north, has some very lovely 17th-century almshouses, and tweed is still woven there.

These towns and villages of the Cotswolds have a most beautiful setting. The rolling upland country has rich reddish soil, and a great variety of wild flowers grows there. Woodlands are mainly beech, with some oaks, sweet chestnuts, and hazel and elder trees. Rivers like the Windrush and Evenlode flow through delightful valleys, and to the north are wonderful views across the Vale of Evesham to Wales. Indeed, there is little wonder that the Cotswolds are considered one of England's loveliest districts.

The ageless architecture of the Cotswolds – stone cottages at Withington

Sheep grazing in a grass-verged Cotswold lane

ALESSANDRO VOLTA

YOU do not have to look far to find a reminder of the life of Alessandro Volta. Look at the light bulb in your room, the battery of your torch, or numerous other pieces of electrical equipment. You will find written on them the pressure of electricity they use measured in *volts*. This unit of electrical measurement is called after the great Italian scientist, Alessandro Volta.

Alessandro Volta was born in 1745 in Como, Italy. He was not particularly clever as a child, but at 17 he could speak Latin, German, and French as well as Italian. At about this age he became interested in physics, and especially in electricity. By repeating the experiments of Galvani and others (see page 2688) he began to acquire a thorough understanding of everything that was then known about electricity. By the time he was 29 he had become a teacher of physics at the high school in Como, and five years later he left Como to join Pavia University as the first Professor of Physics there.

At this time only the effects of static electric charges were known. These charges could be produced by rubbing glass or amber with silk or fur, but no one had been able to measure how much electricity was present in them.

Volta's early experiments

Volta made an *electrometer* (now called an electroscope) to measure these electric charges. In his first electrometer he arranged for the charge that he wanted measured to be shared between two straws, and since like charges repel one another, he could measure the size of the charge by the distance that the straws moved apart. Volta later replaced the straws by two pieces of gold leaf. When these were charged with electricity the angle between them gave a measure of the size of the charge.

Working on the measurement of electricity naturally led Volta to an interest in its production. He found that static electric charges could be transferred on to insulated metal plates; he called the device which he used for doing this an *electrophorus*.

Volta continued the experiments started by Galvani using muscles and nerve fibres from frogs' legs. Galvani had discovered that an electrically charged piece of metal placed on the nerve made a dead frog's leg twitch. Volta obtained the same effect by touching the nerve at two different points with strips of two different metals (for example, silver and copper), the other ends of which were in contact with each other. When he was describing the results of this experiment he said: 'It is clear that the cause of this flow of electricity is the metals themselves.'

Alessandro Volta (1745–1827)

Volta repeated this experiment using his own tongue in place of the frog's leg. He found that one metal produced an acidic taste and the other an alkaline taste, and that the strength of the taste varied with the pairs of metals. He found that the pairs of metals which gave a strong taste also caused a large twitch in the frog's leg. Volta experimented with many different metals and with carbon, and then arranged these substances in a series, ranging from those that gave a strong acidic taste at one end to those that gave a strong alkaline taste at the other. Two metals a long way apart in this series would cause a large twitch in the frog's leg, and two metals close together only a small twitch. The metal from the 'acid' side of the pair would always have an acidic taste, and the other an alkaline taste. This arrangement is now known as the *Voltaic series*.

DID YOU KNOW?
As well as the volt, other units of electricity are named after people: the ampere *after the French physicist, Ampère* (1775–1836); *the* ohm *after the German physicist, Ohm* (1787–1854); *and the* watt *after the Scottish engineer, James Watt* (1736–1819).

The Voltaic pile

Eight years later Volta announced his invention of a new apparatus which could supply a steady flow of electricity; this was a pile of copper and zinc discs. Each copper disc was laid on a zinc disc, and between each pair was a piece of cardboard soaked in salt water. This was known as a *Voltaic pile*, and was the forerunner of the dry batteries we use today.

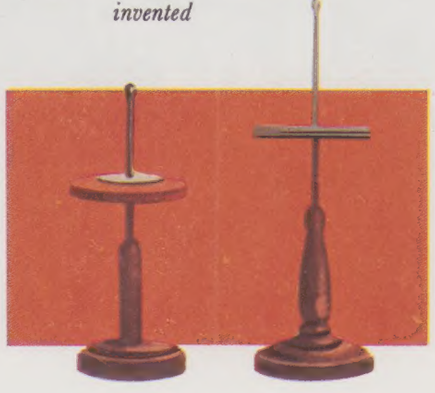
The publication of these results in the *Philosophical Transactions* of the Royal Society in London brought Volta much fame, and an invitation to go to Paris and lecture at the Academy before a distinguished audience including Napoleon.

Later life

Volta had two sisters who were nuns and a brother who was a monk, and like them he seemed uninterested in worldly pleasures – his only loves being study and teaching. However, when he was 50 he married Teresa Peregrini and for the rest of his life became devoted to his family. He even tried to give up active research, and in 1804 he begged to be relieved of his professorship in Pavia, only to be informed by Napoleon: 'I cannot agree to Volta's resignation . . . a good general must die upon the field of honour.' In 1815 he was appointed director of the philosophical faculty of the University of Padua.

Only for the last eight years of his life was Volta able to live in his home town of Como, where he died at the age of 82 after a peaceful retirement.

Two models of the electrophorus *which Volta invented*



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The finest hour

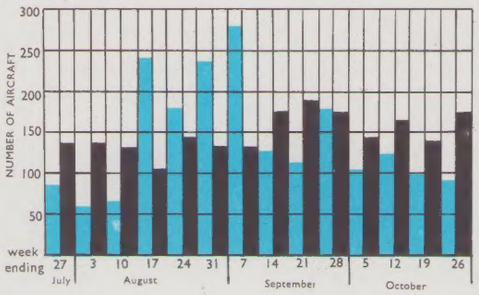
France surrendered before the end of June 1940. The Germans could now base their aircraft 20 miles from Britain, whereas British bombers had to travel five times that distance to reach Germany. Moreover, with Italy in the war (10th June), RAF resources were stretched even further to cover the Mediterranean theatre against overwhelming odds.

But the immediate need was to defend the homeland. The official German report stated: 'It will take between a fortnight and a month to crush the Royal Air Force.' The Germans decided to launch a full-scale aerial attack in August, prior to a sea-borne invasion (Operation 'Sealion') in September.

The Battle of Britain began in earnest on 12th August. At that time the RAF had 620 Hurricanes and Spitfires to oppose the *Luftwaffe's* 3,500 fighters and bombers pitted against them.

Day after day wave after wave of bombers came over in broad daylight, aiming their attacks at RAF stations and airfields. British pilots took off to meet them, often at only seconds' notice, often many times a day, often against odds of 40 and 50 to 1. The brunt of the fighting was borne by the Number 11 Group of Fighter Command, based in south-east England. Between 11th and 14th August the *Luftwaffe* sent over an average of 400 planes a day. On 15th came a series of massed attacks against which Fighter Command made no fewer than 899 sorties.

In nearly every sortie made German losses were heavier than British, but British resources were far weaker. Reserves were being eaten up, and the shortage of pilots was acute. The new Ministry of Aircraft Production, under Lord Beaverbrook, had been set up in May, but by September the situation looked grave.



PRODUCTION AND WASTAGE OF SPITFIRES AND HURRICANES, JULY–OCTOBER 1940

Gross weekly output of Spitfires and Hurricanes

Gross weekly wastage of Spitfires and Hurricanes

Suddenly, on 7th September, the Germans switched from daylight raids on airfields to attacks, mainly by night, on British cities. London was the first to be attacked, and the blitz was continued night after night on London and cities like Coventry, Plymouth, Birmingham, Portsmouth, and Bristol. At the same time large concentrations of barges were observed building up in the Channel ports. The 'area' bombing of British cities was clearly a 'softening-up' process, preliminary to the invasion.

The new direction of attack gave the RAF time to build up its resources and reserves. British bombers attacked the barges and gradually they dispersed. By 31st October the RAF's losses in the battle had mounted to 915 fighters and bombers. But the Germans had lost 1,733, and they had failed to win command of the air. Without it invasion was impossible. Operation 'Sealion' was postponed indefinitely, and, although the British civilians, particularly in London, faced a grim winter of almost continual bombing, the RAF was being strengthened all the time, and by the spring of 1941 it was generally considered that the worst of the *Luftwaffe* menace was over.

1944 – the RAF helps the army. Parachute troops are dropped over Holland

From defence to attack

Even when the Battle of Britain was at its height, British bombers were able to retaliate against Germany. RAF leaders were not keen on these retaliatory raids, but the British government regarded them as an important morale booster. After June 1941, when the bulk of the German *Luftwaffe* was directed to the eastern front to support the Russian campaign, the RAF was able to think seriously of striking back on a large scale. It soon gained mastery over Britain at night, by using Beaufighters equipped with airborne interception radar. During 1942 the RAF obtained its 'big lift' Stirling and Lancaster bombers, which enabled it to deliver devastating attacks on Germany. These attacks took place mainly at night. They became increasingly accurate and effective, thanks to the fast and accurate Mosquito Pathfinders and the use of radar precision bombing aids.

The first 1,000-bomber raid was made on Cologne on 30th May 1942. By 1943 the United States Air Force was able to begin its own large-scale bombing of Germany. At first American 'Flying Fortress' bombers, heavily equipped with guns, flew in broad daylight without escort. Such raids proved so costly that eventually escorts

Air Chief Marshal Sir Hugh Dowding, Fighter Command

Wing Commander Guy Gibson – leader of the Dambusters

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of fighters were provided. The combination of American bombing by day and British by night proved a great handicap to the German war effort. Towns like Dusseldorf, Hamburg, Essen, Dortmund, and Duisburg were bombed almost into rubble heaps. In all, nearly 1 million tons of bombs were dropped by Bomber Command during the war. Air Chief Marshal 'Bomber' Harris had to argue fiercely to keep this 'Battle of Germany' going, but it did succeed in creating havoc in the German war machine. One of the most thrilling moments of the war was the Dambusters' raid on the night of 16th–17th May 1943. Wing-Commander Guy Gibson commanded a force of 19 Lancasters which dropped revolutionary bombs that skipped across the water like pebbles and shattered two of the three mighty dams upon which depended the entire water supply of the great industrial regions of the Ruhr. The third dam was damaged. Eight of the Lancasters failed to return. Wing-Commander Gibson was awarded the VC, and all the surviving members of the crew were decorated.

Nevertheless, not all the energies of the RAF could be concentrated on attacking Germany directly. Fighter Command had proved its power during the Battle of Britain; Bomber Command was disrupting sections of the German war effort; but it was Coastal Command and the Navy's Fleet Air Arm that played a major role in one of the most decisive operations of the war – the Battle of the Atlantic.

Certain sectors of German opinion had never believed that the *Luftwaffe* could crush Britain, and Admiral Raeder had given the extreme opposite opinion by claiming that the U-boat submarines alone could win the war. During 1941 and 1942 immense quantities of British shipping were destroyed. At the same time, serious losses in North Africa and the Mediterranean region, where Air Force resources were totally inadequate, forced some supplies for Britain to go round the Cape instead of through the Mediterranean. At one point British and American supplies were being destroyed at such a rate that it seemed impossible for Britain to remain in the war. But many lessons were learned during the war, and among them that air power could be used against sea power. RAF planes, in conjunction with the United States Air Force, were constantly on the alert for enemy warships, and by 1943 had succeeded in making it extremely dangerous for U-boats to surface, even by night. In 1941 aircraft played a large role in the destruction of the battleship *Bismarck*. In 1942 a heroic group of six Swordfish aircraft of the Fleet Air Arm attacked three mighty German battleships: the *Scharnhorst*, *Gneisenau*, and *Prinz Eugen*. All six aircraft were lost, and the leader of the raid, Lt-Cdr E. Esmonde, was awarded the VC posthumously.

During the war Coastal Command claimed 243 out of 866 enemy submarines destroyed, and it also sank 1,518 surface vessels totalling 1,750,000 tons.

FIRST-LINE AIRCRAFT, BRITISH AND GERMAN

Date	*RAF*	*German*
1st June 1944	8,339	6,967
1st January 1945	8,395	6,638

The final lap

By 'D-Day' (6th June 1944) the Allies had obtained complete air superiority. New ground-attack fighters, like the Hawker Typhoon, added a powerful force to land warfare with their rocket strikes against fortifications, armour, troops, and communications. Towards the end of the war jet aircraft, like the Gloster Meteor, were introduced. These proved useful in intercepting and destroying the sinister V1s ('flying bombs'), launched after 13th June 1944 by the Germans. The RAF had no defence to offer against the phenomenally fast V2s launched in the autumn, but by then it was too late. Germany capitulated on 7th May 1945. A few months later, on 6th August 1945, the first atomic bomb was dropped on Hiroshima, and the Japanese surrender was imminent. This bomb was ten times more powerful than the first RAF 1,000-bomber raid on Cologne three years before. So, with the rocket and with nuclear power, a new age had begun: the challenge the RAF is facing now.

SOME OF THE MAIN AIRCRAFT USED IN THE SECOND WORLD WAR

AIRCRAFT	MAXIMUM SPEED	SERVICE CEILING (in feet)
BRITISH		
BATTLE (fighter)	341 mph at 13,000 ft	23,000
BLENHEIM (fighter and bomber)	266 mph at 11,800 ft	26,500
HURRICANE (fighter)	339 mph at 22,000 ft	35,600
LANCASTER (bomber)	289 mph at 11,000 ft	20,000
METEOR (jet fighter)	476 mph at 30,000 ft	44,000
MOSQUITO (fighter and bomber)	370 mph at 14,000 ft	33,500
SPITFIRE (fighter)	375 mph at 20,250 ft	38,000
TYPHOON (fighter-bomber)	405 mph at 18,000 ft	33,000
WELLINGTON (bomber)	247 mph at 17,000 ft	20,000
GERMAN		
DORNIER 217 (bomber)	305 mph at 18,000 ft	21,500
FOCKE-WULF W190 (fighter-bomber)	385 mph at 18,000 ft	36,000
HEINKEL HE111 (bomber)	240 mph at 14,000 ft	26,000
MESSERSCHMITT ME109 (fighter)	355 mph at 18,000 ft	35,000
MESSERSCHMITT ME262 (jet fighter)	550 mph at 29,000 ft	–

The RAF played a decisive role in the Battle of the Atlantic. Here a German warship is under attack from RAF Beaufighters